siderations of atmospheric conditions and health, there are the broader and more general aspects of climate and the treatment of certain diseases. Professor Ward, in the address earlier referred to, emphasized the correct understanding of the characteristics of climate and the judicious selection of climates to suit the particular ailments, for there is no "perfect" climate that will be equally beneficial for all ills.

Efforts have been made frequently to give graphical representations of climatic characteristics, especially with regard to temperature and humidity, and some of these have been very successful. Perhaps the *climograph* of Dr. Griffith Taylor, of Australia, is the most noteworthy example. Mr. B. M. Varney[8] says:

> One scarcely need point out the great usefulness, to the geographer, the business man, the physician, the teacher, any device which helps to create living conceptions of the nature of climate and weather, so leading to a better estimate of the effect of a given atmospheric environment on human affairs.

That is what the climograph seeks to do. It is a chart in which wet-bulb temperatures are plotted against relative humidity, or air temperature (dry-bulb) against relative humidity. Mr. Varney has chosen to mark certain regions of his climographs "raw," "keen," "scorching," "muggy," etc., to indicate bodily sensation. The line joining the points in the diagram wanders about among these regions and thus indicates the characteristics of the weather or climate under consideration.

Dr. Carrol E. Edson, president of the American Climatological and Clinical Association, at the meeting of the Meteorological Society mentioned above, gave the following questions as being worthy of study by the meteorologist, and referred to them as gaps in present medical knowledge:

1. Is basic metabolism different in people living at high altitudes from that of people living at low altitudes? A study of this might be called "Climatic physiology."

2. What is the effect of sudden changes—changes of altitude, temperature, moisture, wind, etc.? Experimental solution of this question is possible. This is "Physiologic meteorology."

3. Lastly, there is the study of the adaptability of the diseased mechanism to meet sudden changes: "Medical climatology."

These are a few of the aspects of the relations between meteorology and health, and indicate what an extensive field there is for investigation, both for the meteorologist and the physician.

C. LeRoy Meisinger
Washington, D. C.

[8] "Some Further Uses of the Climograph," *Monthly Weather Review*, September, 1920, pp. 495–497.

SPECIAL ARTICLES

A NEW TYPE OF INHERITANCE

In a recent contribution from the Carlsberg Laboratory,[1] J. Schmidt has described a new type of inheritance found in "the millions fish," *Lebistes reticulatus*, from Trinidad. A conspicuous black spot occurs on the dorsal fin of the male in one race of this species, but it is wanting in all females of the species and also in males of a second race with which crosses were made. This spot was transmitted to all male offspring of the spotted fish, regardless of the mother's ancestry, but it was not found in the female offspring, nor did it reappear in the male offspring of such females, when they were mated with males which lacked the spot.

Further, sons of the spotted male, transmitted the spot to *all* their male offspring, not to half of them, as would be the case with an ordinary dominant Mendelian character. The inheritance of the character appears to be exclusively from father to son, females neither possessing nor transmitting it. Evidently the sperm is the sole vehicle of its transmission. It does not get into the egg at all. Moreover it is apparently transmitted by only *half* the sperm cells, those namely which are male determining in function. It therefore has, as Schmidt points out, exactly the distribution of a Y chromosome, and he suggests that a Y

[1] *C. R. Travaux Laboratoire Carlsberg*, Vol. 14, No. 8, Copenhagen, 1920.

chromosome may be the vehicle of transmission, a matter which his colleague, Winge, has under investigation.

In all previously known cases of sex-linked inheritance, the egg as well as the sperm may serve as a vehicle of transmission. In *Drosophila* and man it is supposed that the X chromosome bears sex-linked characters, the female being in formula XX, so that every egg after maturation contains an X, a bearer of sex-linked characters; but in the same species the male is XY in formula, a Y replacing one of the X's found in the female. This X consequently will occur in only half of the sperm produced by the XY male, namely those which pass into female offspring, but the other sperms will contain Y instead of X and they will pass into male offspring. However, up to the appearance of Schmidt's paper, no characters had been observed to follow the path of a Y chromosome in transmission, so that Morgan characterizes the Y chromosome of *Drosophila* as "empty."

Before the mechanism of transmission of sex-linked characters had been worked out, I suggested in 1909[2] that the Y chromosome afforded a suitable vehicle for transmitting the secondary sex characters of males. But until Schmidt's publication was made this suggestion had found no support in known facts, and the demonstration by Morgan and others that characters which make their first appearance or are most often found in males, may nevertheless have their genetic basis in an X chromosome, seemed to discredit the Y chromosome as a possible organ of inheritance. The discovery of Schmidt leads me to call attention to my earlier suggestion, not for the mere satisfaction of saying "I told you so," but to renew the further suggestion which I then made and which still lacks verification, that the Y chromosome may contain the clew to the explanation of that other and very different type of sex-linked inheritance found in *Abraxas* and subsequently found to occur also in poultry.

[2] "A Mendelian View of Sex-heredity," SCIENCE Vol. 29, pp. 395–400, March 5, 1909.

Studies of sex-determination made in the last twenty years show unmistakably that in diœcious species the chromatin composition of the nucleus of the egg determines the sex of the individual into which the egg develops. Further, in many cases, if not in all, the quantity of chromatin is clearly decisive between maleness or femaleness in the individual which develops from the egg. Thus in parthenogenesis an egg which develops without chromatin reduction (in maturation) regularly develops into a female; but an egg which first undergoes chromatin reduction (usually by exactly half the total number of chromosomes), before it begins development into an embryo, if it remains unfertilized, now develops into a male. Yet if the egg, after undergoing chromatin reduction in maturation, receives a new complement of chromatin by being fertilized, it is restored again to the female status. Femaleness thus goes with the full chromatin equipment of the species, maleness with a less complete chromatin equipment.

It has further become clear through studies of sex-linked inheritance that not all kinds of chromatin are equally influential in determining sex, but that a particular chromosome called X is of preëminent, if not exclusive importance in determining sex. In the case first clearly worked out by Wilson, that of the squash-bug, the female bears in each cell-nucleus a pair of X's, whereas the male contains but one. As the remaining ten chromosomes of this species are paired in both sexes, the total chromosome count for the female is $20 + 2X = 22$; for the male it is $20 + X = 21$. The only discoverable difference between the two sexes is in the number of the X chromosomes. The number is two in the female, one in the male. The metabolic grade of maleness is attained when, in addition to the other ten pairs of chromosomes, a single X chromosome is present in the cell, but the grade of femaleness is attained only when the further addition of a second X is made. Every kind of chromatin of the species is present in the male, but a particular kind of chromatin is present in less

amount in the male than in the female. Now if the only difference between the two sexes lies in one chromosome, it is conceivable that one X might be dropped from each sex, without disturbing the sex balance. Besides the paired chromosomes which were alike in both sexes, the female would now contain one X, the male none. It is possible that this hypothetical simpler condition actually preceded the other, that the X chromosome really was at first a structure developed in the egg and handed on by this route from mother to daughter as an exclusively female structure, very much as extra-nuclear structures or plastids (chromatophores) are handed on in certain plants, or in the egg of the green hydra, being never found in the male gamete. It may be also that this condition is realized in birds and moths, but of this more later.

Now Wilson has shown, by comparative studies of the sex-determining mechanism of insects, that the single unpaired X of the male is apt to acquire a mate which he calls Y, of unknown origin and function but certainly of different nature from X. This is frequently much smaller than its synaptic mate, X, but in other cases is almost or quite as large as X, so that the chromosome count shows the same number of pairs in both sexes. Only comparative studies, coupled with experiments in sex-linked inheritance, show that throughout the series there is an odd or single X in the male, while in the female there is a pair of X's. The Y chromosome, which makes its appearance as a mate of the odd X, is now a purely male structure, counterpart of the hypothetical original single X of the female, and Schmidt's observations show that such a structure may perfectly well be a vehicle of transmission in heredity of characters which are the exclusive possession of males. For males would now form (as in *Drosophila*) two kinds of sperm, differing only in one respect. One type containing X would be female determining, the other type containing Y would be male determining when respectively they fertilized the single type of mature egg, which contained one X. If, however, by non-disjunction in maturation an egg retained two X's and was fertilized by a Y sperm, it would of necessity develop into a female (2X) (as is the case in *Drosophila*, Bridges) which nevertheless would possess inherited characters previously possessed only by males, because of the presence of the Y. Eggs of this character might (as in *Drosophila*) produce four types of gametes, viz., XX and Y, or X and XY. Sperm also (as in *Drosophila*) might be produced of the classes X, Y, and XY. A great variety of possible combinations would result, as Bridges has shown in cases of non-disjunction in *Drosophila*. Of these various combinations, two sets might give rise to stable self-perpetuating systems of the *Abraxas* type, viz., (1) female XX-Y, in which the two X's are permanently united into a single body which acts as the synaptic mate of Y, while the male is Y-Y in formula; or (2) female X-Y with an increased potency of X sufficient to determine femaleness in single dose, male Y-Y. It is true that in *Drosophila* Bridges finds Y-Y zygotes non-viable but this is no evidence that Y-Y zygotes would be non-viable in all organisms. It is also true that he finds that the non-disjoining X's may later separate, but this would not preclude permanent union of two X's in other organisms.

On the other hand, it is conceivable that the poultry type of sex-linked inheritance may not have been derived from the *Drosophila* type at all but from a simpler primitive condition in which the female bore one X, the male no X. If in a species of this type, a Y chromosome appeared in the egg as the synaptic mate of X, it would necessarily go exclusively into those eggs which were to become males and would thus seem to be an exclusive male possession even though it had originated in a female. But the male which had received Y from his mother would now produce two types of sperm, Y and no-Y. An egg transmitting Y, if fertilized by sperm also Y would produce a Y-Y male, which might prove to have greater survival value than the male which contained no Y or only a single Y. If this happened, the race would become permanently, female X-Y, male Y-Y, which in

so far as Y is concerned is exactly the condition demanded in the poultry type of sex-linked inheritance for a carrier of sex-linked characters. This line of thought leads to the following hypothetical outline of the evolution of sex-linked inheritance.

1. Sex-linked inheritance begins with the inclusion in the nucleus of the egg of a structure, X, perhaps originally found in the cytoplasm and handed on there from egg to egg in the female line, never in the male line. This structure is itself (or is attached to) the specific determiner of femaleness; it is an element which keeps the organism at the metabolic level of femaleness, its absence allowing the organism to drop down to the metabolic level of maleness. Characters (genes) located in X would pass only from mother to daughter.

2. From the foregoing state two divergent lines of evolution may have arisen.

(*a*) In one the X chromosome becomes duplicated in the female (perhaps by splitting at the reduction division) and is in consequence found in all eggs after maturation. It thus passes into male zygotes as well as female zygotes. The female will now be XX in formula, the male XO. Whatever inherited characters have their genes located in the X chromosome will now be transmitted as in *Drosophila* and man.

(*b*) A chromosome, Y, not concerned primarily in sex-determination, may develop as the synaptic mate of X in the egg; it would at once pass into male offspring and being transmitted in sperm cells would speedily produce the male type Y-Y. But in the female, Y would be kept from becoming duplex by the presence of X, the synaptic mate of Y. If Y contained genes, these would be transmitted as are the genes of sex-linked characters in poultry and other birds and in moths.

3. If in the *Drosophila* type of inheritance, Y should come to contain genes, these would be handed on from father to son, without ever entering a female zygote (*Lebistes* type). In the poultry type of sex-linked inheritance, Y would not afford a suitable mechanism for this one-sided type of inheritance, since Y there passes into females. Hence the *Lebistes* type must be a further evolution of the *Drosophila* and human type, not of the poultry type.

W. E. Castle

Bussey Institution,
March 1, 1921

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SECTION A AND ASSOCIATED MATHEMATICAL ORGANIZATIONS

Section A of the American Association for the Advancement of Science met in Chicago on Wednesday morning, December 29, in joint session with the American Mathematical Society (Chicago Section), the Mathematical Association of America, and a group of persons interested in the History of Science.[1] Professor D. R. Curtiss, chairman of the Section, presided. Professor O. D. Kellogg, of Harvard University, the retiring chairman, gave an address entitled "A decade of American mathematics." Professor Florian Cajori gave an illustrated address on "The evolution of algebraic notations." This meeting was attended by more than 200 persons, including 80 members of the American Mathematical Society and 150 members of the Mathematical Association of America.

At the business meeting following the program, the nominations made by the sectional committee (on December 27) were approved. These nominations, which were acted upon by the council of the association at its meeting of December 31st, were as follows:

I. For Chairman of the Section, who will preside at Toronto and give his retiring address at Boston, Oswald Veblen, Princeton University.

II. For Secretary of the Section, who will hold office until the meeting of 1924–25, William H. Roever, Washington University.

According to the new constitution four instead of five members, in addition to the chairman and secretary, constitute the Sectional Committee. Therefore it was unnecessary to elect a member to succeed Professor H. L. Rietz, whose term expired with the Chicago meeting. The four members are: Dunham Jackson (January, 1920, to December, 1924), Minneapolis, Minn.; A. D. Pitcher (January, 1920, to December, 1923), Cleveland, Ohio; Gilbert A. Bliss (January, 1920, to December, 1922), Chicago, Illinois; James M. Page (January,

[1] Science, February 18, 1921 (p. 164).